distance of BC was less than 11″; and about the middle of that century it was a little less than 9″.

The measures of CD do not cover a sufficient time to tell with certainty what the relation of D is to this group. As the angle of CD is nearly in the line of the motion of C, the distance between these stars should be about 0″·2 more in 1890 than in 1888, if D does not share the motion of C; but from the measures this distance is 0″·5 less at the former date. This would appear to indicate that the proper motion was common to both stars, and that there was a relative change due to some other cause. Measures made two or three years hence will at once settle this question.

The Herschel companion is the star generally used for the determination of the differential parallax of *Aldebaran*; but as the proper motion of the small star does not appear to have been taken into account, the result obtained would seem to be materially affected by an error from this source.

Mount Hamilton: 1890 *December* 25.

The Orbit of κ Pegasi (β 989). By S. W. Burnham.

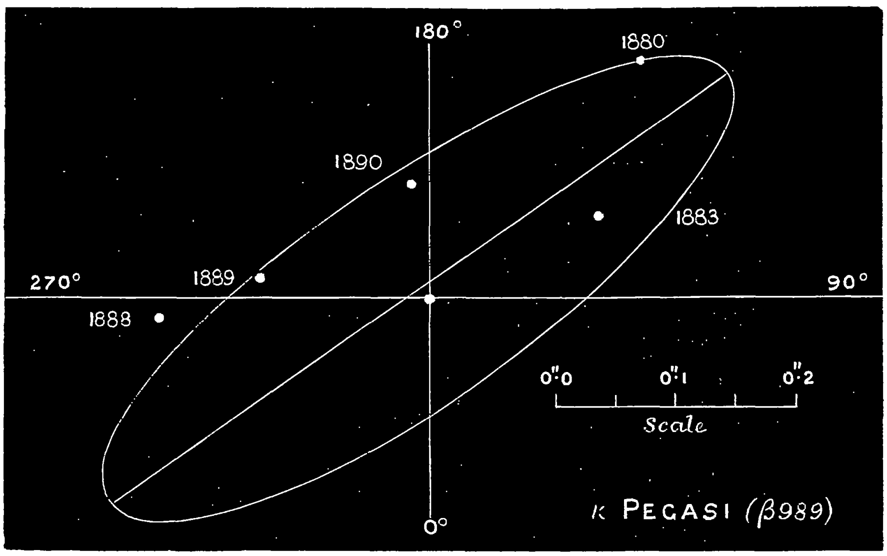
On August 12, 1880, while observing with the 18·5-inch refractor of the Dearborn Observatory, I came across the wide pair, κ *Pegasi*, and at once saw that the large star was a very close double. The measures made on this and following nights gave a distance of 0″·27, and this I thought was more likely to be too large than otherwise (*Monthly Notices*, xli. p. 33). I was unable to give any further attention to this star until the commencement of my measures made at the Lick Observatory, and the extreme difficulty of measuring so close a pair seems to have deterred other observers, with a single exception, from doing anything with it. The only record of any other observation of any kind is found in the work of the late Dr. Engelmann, of Leipzig. When we consider that his telescope had an aperture of only about 7·5 inches, it is almost wonderful that he could get even an approximate position, notwithstanding it was a Clark objective, and shows his great skill as an observer, and the superior defining qualities of his instrument. It is unfortunate that we have so little to represent the extraordinary motion of this pair in a few years through an angle of 230°. Since I have been at Mount Hamilton I have measured the close pair each year with the 36-inch refractor. During the measures of the past year it was extremely difficult, and was a severe test of the power of the great telescope with the very best atmospheric conditions. The highest powers were, of course, used, and it was necessary not only to exercise the utmost care in

focussing, but to keep the head in such a position that the line joining the eyes was parallel to the line of the two stars.

The following are the measures of the close pair :—

1880·68	137°·9	0″·27	β	4n
1883·02	116·0	0·16	En.	1n
1888·78	274·7	0·23	β	3n
1889·51	262·3	0·14	β	4n
1890·57	187·1	0·10	β	4n

It is plain from the few observations already made that we have a binary system in very rapid motion. It is too soon perhaps to expect from the data given anything more than a very approximate solution of the orbit by any method of investigation, but a graphical representation of the measures will at least give a general idea of the relation between the components.



I have laid down these measures with all possible accuracy on a large scale (1″=20 inches), and then drawn after repeated trials the apparent ellipse shown on the accompanying diagram. This ellipse satisfies the test of equal areas in equal times. The areas described by the radius vector between the position of 1880–89 and 1889–90 are exactly proportional to the times (1 : 8·33); and as the variation of these positions from the path described by the curve is far within the ordinary errors of observation in a much easier star than this, I think the figure may be taken as a fair approximation to the apparent motion of the components. According to this diagram, the distance at the time of Engelmann's measure was 0″·23, and the angle 113°; while for the position of 1888 the distance is 0″·21, and the position angle 281°. The other measures are substantially exact with reference to the assumed path of the secondary star. The

components differ in brightness by something less than one magnitude, and when they are separated by only a quarter of a second, the difference is not very plain. It might be suspected that the angle of 1880 should be increased 180°, or that the measures of the last three years should be diminished by that amount. Upon referring to the original observations, I find that I took special pains to give the proper quadrant at the time of discovery, as well as in the measures of 1888 and 1889; so that I feel every confidence in the accuracy of the observations in this respect.

If this figure correctly represents the relative motions, it is evident that the period is shorter than that of any known star in the heavens. It should make one revolution in a little more than eleven years, and by the time it is observable again during the present year it should have nearly completed one revolution, and have about the same angle and distance as at the time of discovery in 1880.

From the projected orbit we get the following:—

Major axis	0″·636
Minor axis	0″·187
Maximum distance	0″·32 (1881·7)
Minimum distance	0″·08 (1884·6)
Period	11·13 years
Position angle of major axis ...	125°·4

Apparently the real orbit is nearly circular, and makes an angle of about 75° with the line of sight. Whether the period of rotation is as short as that indicated, the motion is certainly very rapid, and the object one of the most interesting of its class. The measures which I hope to make during the coming summer will probably settle most of these questions. It should be comparatively easy to measure this year, as the distance will be not less than 0″·2.

This star has been known as a wide double star since the time of Sir William Herschel, who detected the companion, a star of ninth magnitude, in 1786. He described it as "extremely unequal, the small star almost north, but a little preceding." It was not measured until 1831, when Struve observed it, and incorporated it in his great catalogue as Σ2,824. The distance of the small star at that time was 11″. It has been frequently measured since, the distance now being a little more than 12″, with a very slow diminution of the position angle. An examination of these measures shows beyond all question that the apparent motion of the small star is rectilinear and uniform. The displacement during the interval between Struve's measures in 1831 and mine in 1888 amounts to 2″·08 in the direction of 252°.

This is undoubtedly the movement of the principal star, which has, therefore, an annual proper motion of $0''.036$ in the direction of 72°.

On the Determination of Double Star Orbits from Spectroscopic Observations of the Velocity in the Line of Sight. By Arthur A. Rambaut, M.A.

(*Communicated by Sir. R. S. Ball.*)

I have shown in a paper which I read before the Royal Irish Academy in May 1886 how the relative velocity of the components of a double star is connected with the parallax and the elements of the orbit. In a later paper, published in the *Monthly Notices* of the Royal Astronomical Society for March 1890, I put the results in a more convenient form, and pointed out what velocities we might expect to find in the already known optical doubles.[1] The smallness of these velocities, however, seemed to show that, except perhaps in a very few cases, the spectroscopic observations of these stars were likely to prove extremely difficult.

At the time of writing the latter paper, although Professor Vogel had demonstrated the duplicity of *Algol*, and Professor Pickering the duplicity of β *Aurigæ* and ζ *Ursæ Majoris*, the results were so novel and startling that, although the idea occurred to me of solving the inverse problem—viz., to obtain the orbit from the spectroscopic observations alone—it did not seem to me that the observations were reliable enough to warrant the expenditure of the time which the solution of the question would require.

The beautiful results, however, obtained by Professor Pickering in the case of β *Aurigæ*, and published in the Fourth Annual Report of the Henry Draper Memorial, seem to throw a wholly new light on the question.

The frontispiece of this report contains five figures, the last four of which are reproductions of some of his photographic spectra, and exhibit the nature of the data on which his results depend. These prove at a glance that there is no question about the periodic displacement of the lines, and also show that the amount of the displacement is capable of measurement with very considerable accuracy.

It is, however, the first of these figures with which we are principally concerned at present. This is a curve in which the

[1] At the time of writing this I was not aware of a paper by Professor Niven in the *Monthly Notices* of the R.A.S., May 1874, dealing with the subject, in which he publishes formulæ almost identical with those given in the communications mentioned above.